Joint DUNE-SBND Workshop

September 2, 2015

DEEP UNDERGROUND NEUTRINO EXPERIMENT

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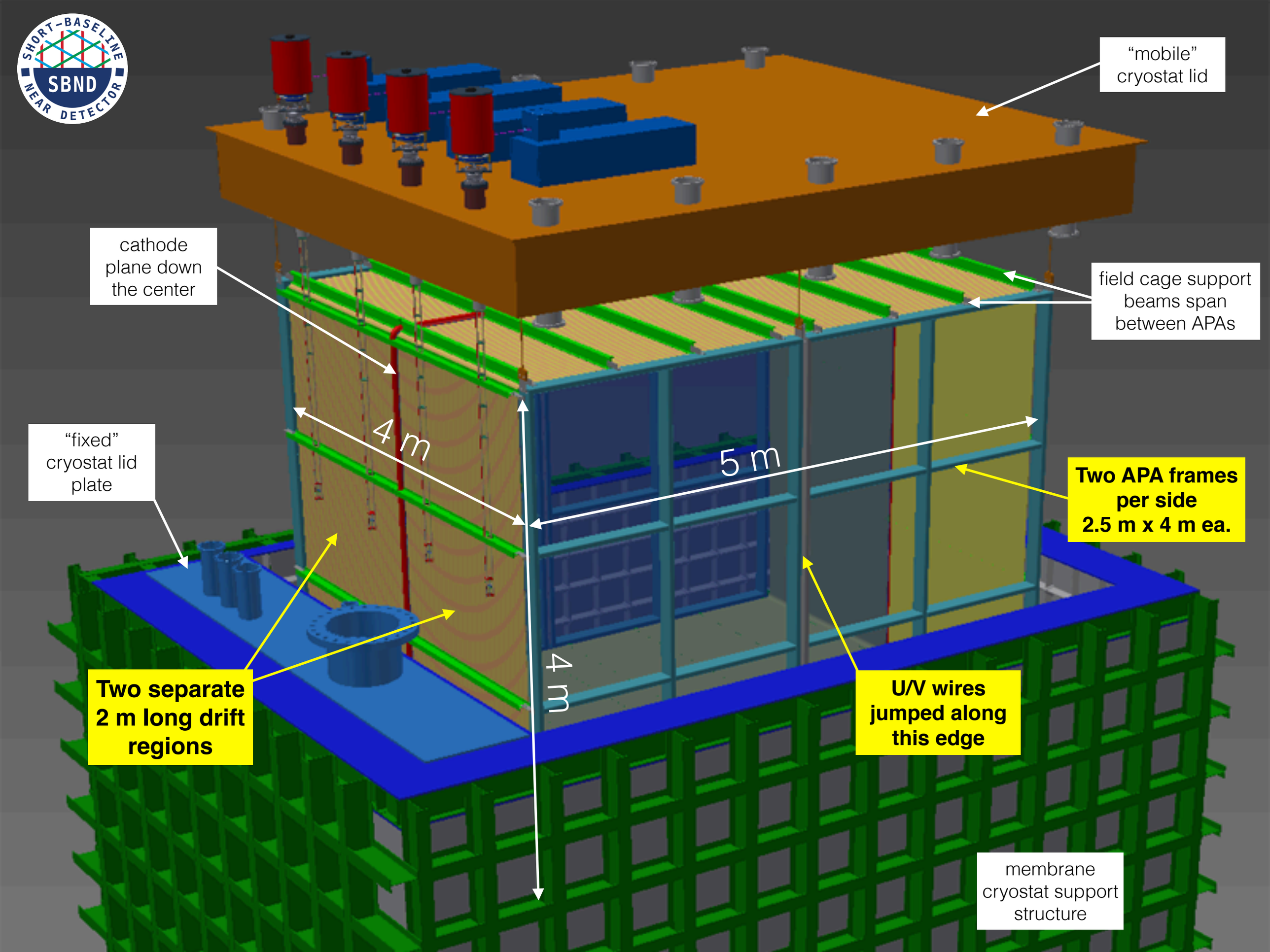
for the SBND TPC Design Team

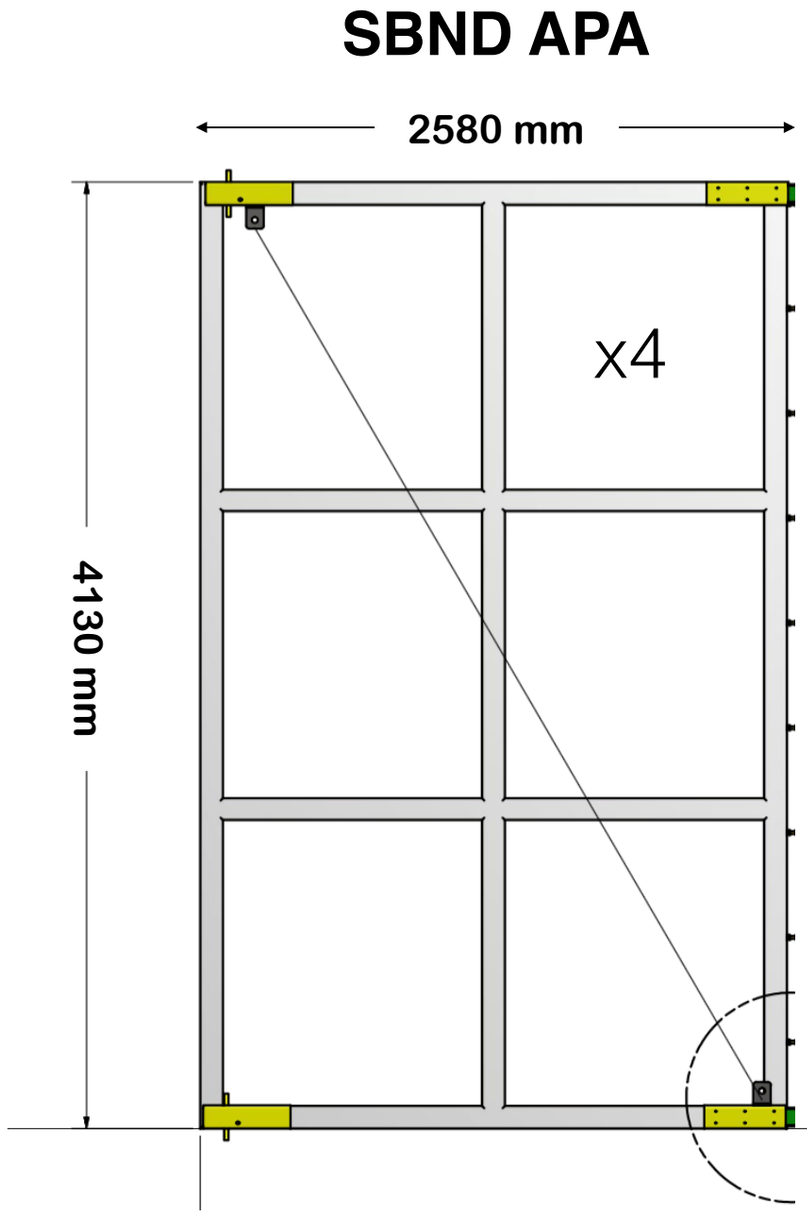
SHORT-BASELINE NEAR DETECTOR SBND

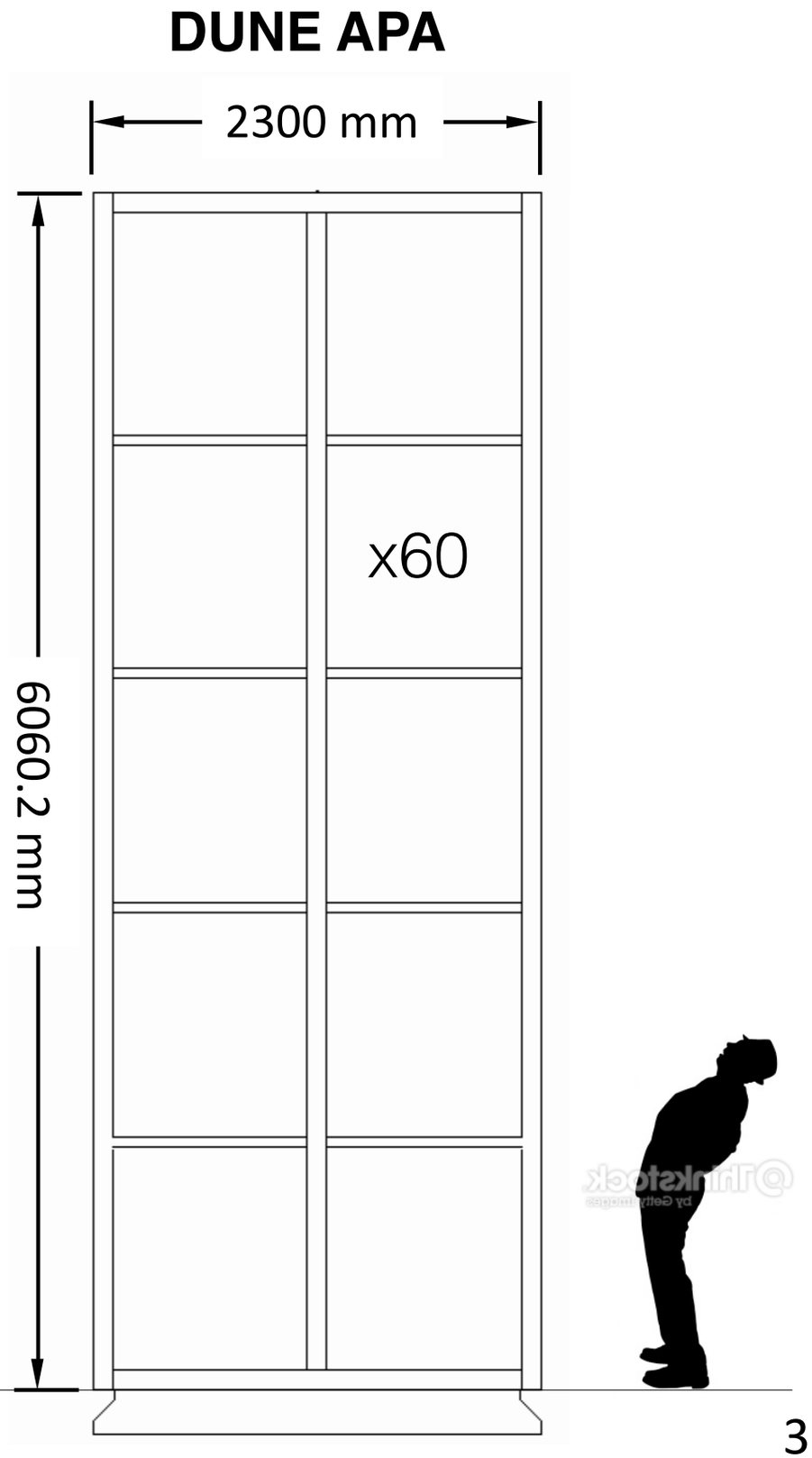

SHORT-BASELINE
SBND
NEAR DETECTOR
“mobile” cryostat lid
cathode plane down the center
field cage support beams span between APAs
“fixed” cryostat lid plate
4 m
5 m
4 m
Two APA frames per side 2.5 m x 4 m ea.
Two separate 2 m long drift regions
U/V wires jumped along this edge
membrane cryostat support structure

SBND & DUNE APA Comparison

SBND APA Summary:

- One-sided wire attachment (i.e. no wire wrapping)
  - 3 wire planes (vert, ±60˚)
  - 3 mm wire pitch
  - 3 mm between planes
- Open back allows light guide or PMT based light collection hardware
- “Tiled” APA frame design to form the TPC
- U/V wires are “jumped” across neighboring APAs, so readout only at outside perimeter of TPC (top and sides)





SBND APA Frames

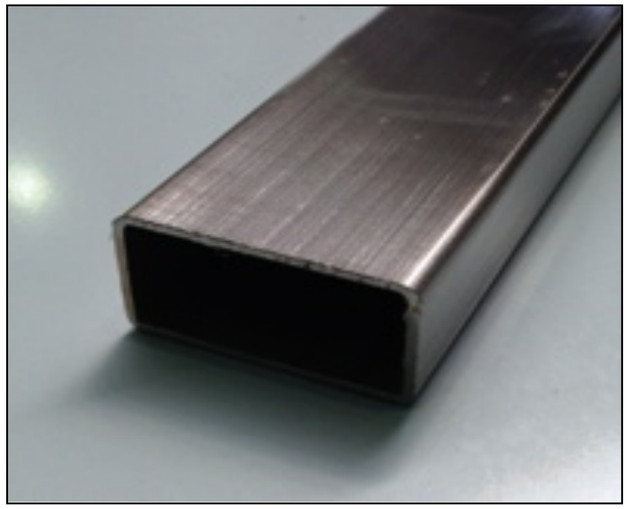
Few Engineering Details:

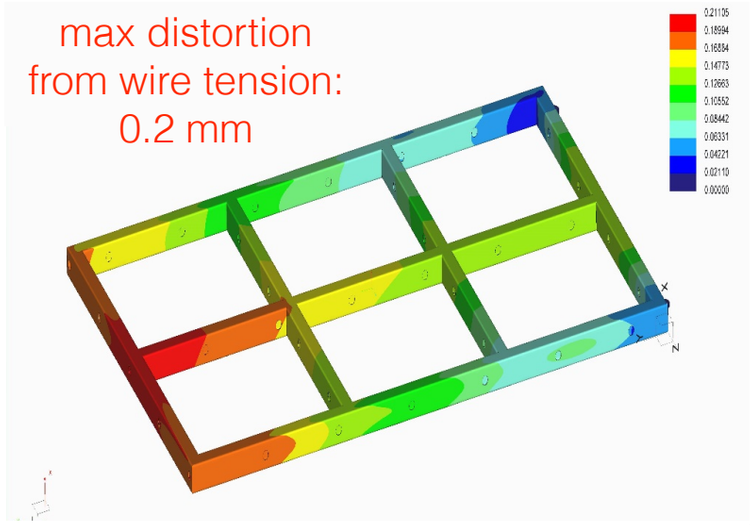
- Constructed from 304 stainless steel rectangular hollow sections (RHS)
  - 150 x 100 mm, 5 mm walls

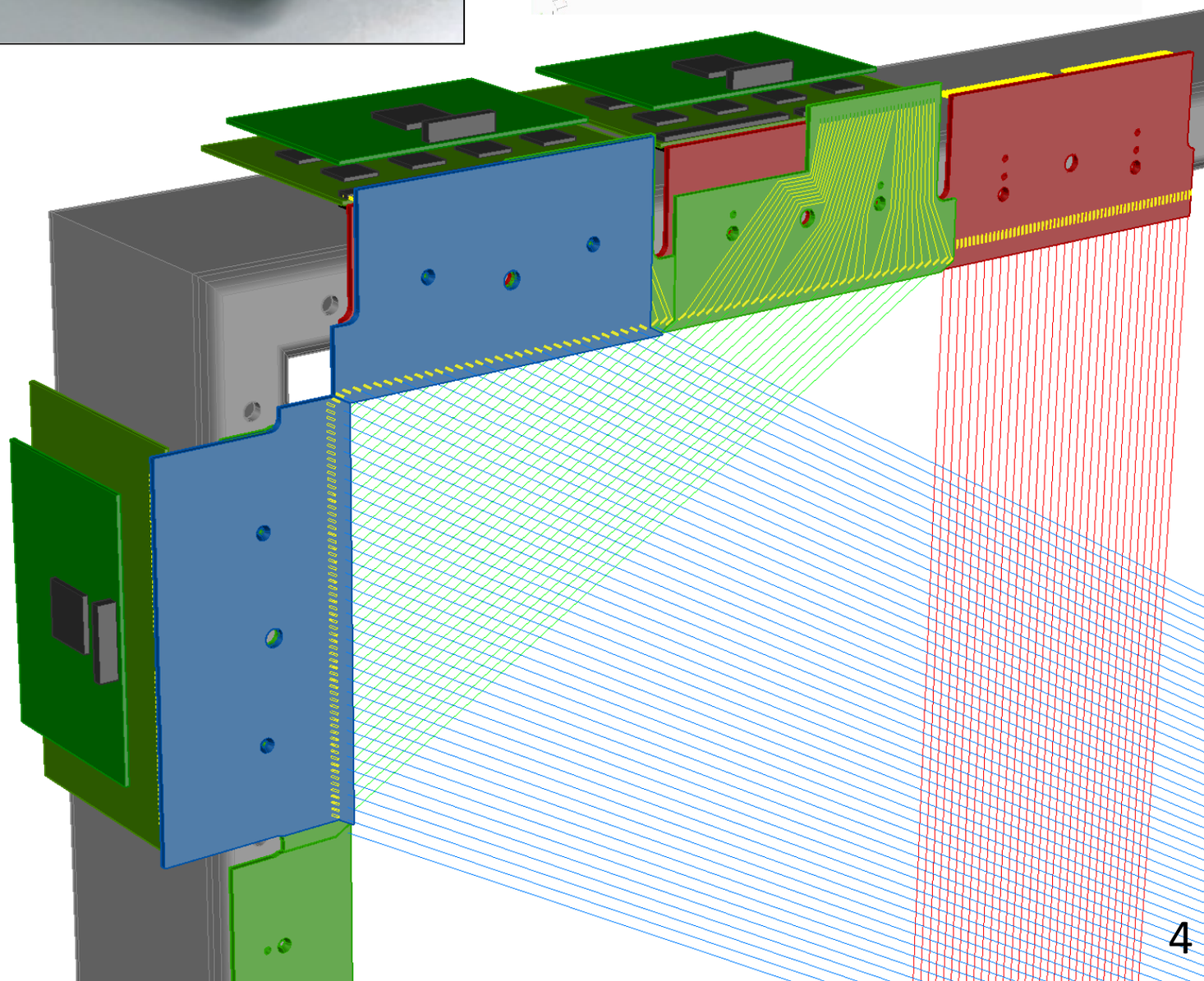
- Bare frame weight = 480 kg
  - incl. interconnection hardware
  - excl. wiring stack, other sub-detectors

- Flatness tolerances on RHS frame provided from UK manufacturer Portobello:
  - 4.0 m length ± 2 mm
  - 2.5 m length ± 1.5 mm

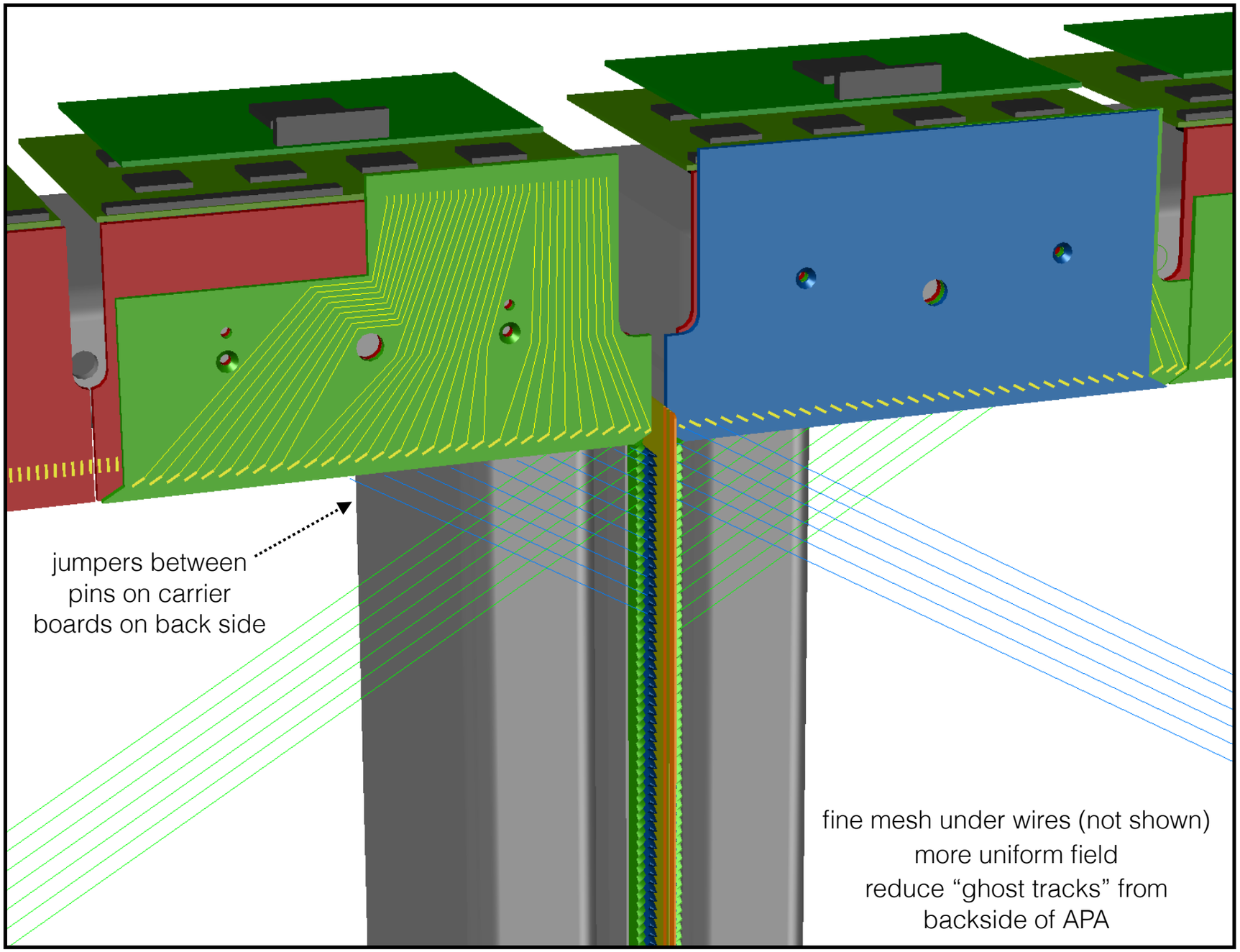
- Wire load: 250 kg/m (0.5 kg/wire)

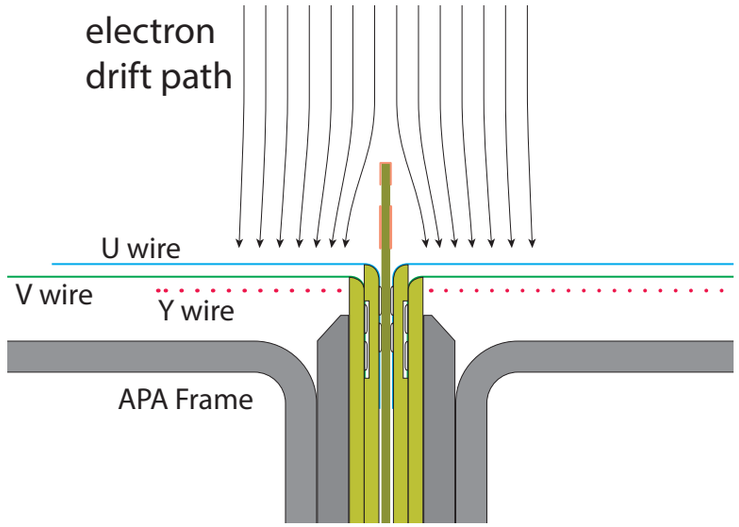


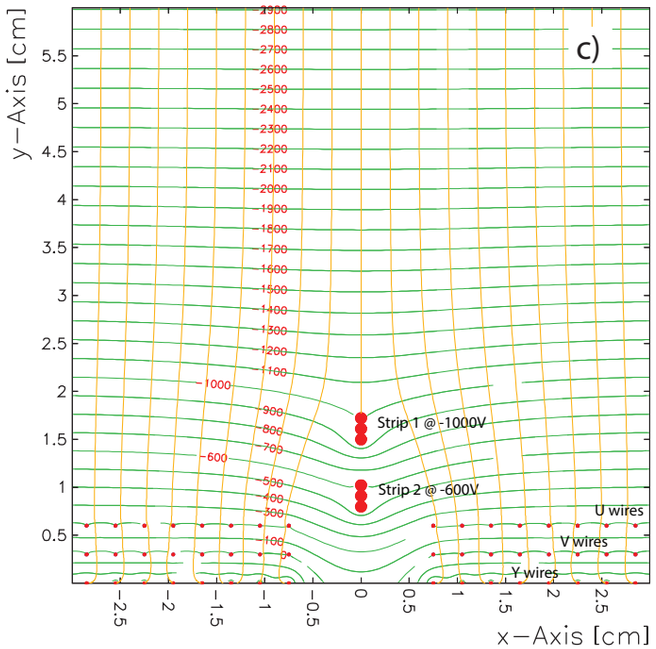




Bridging APA Frames







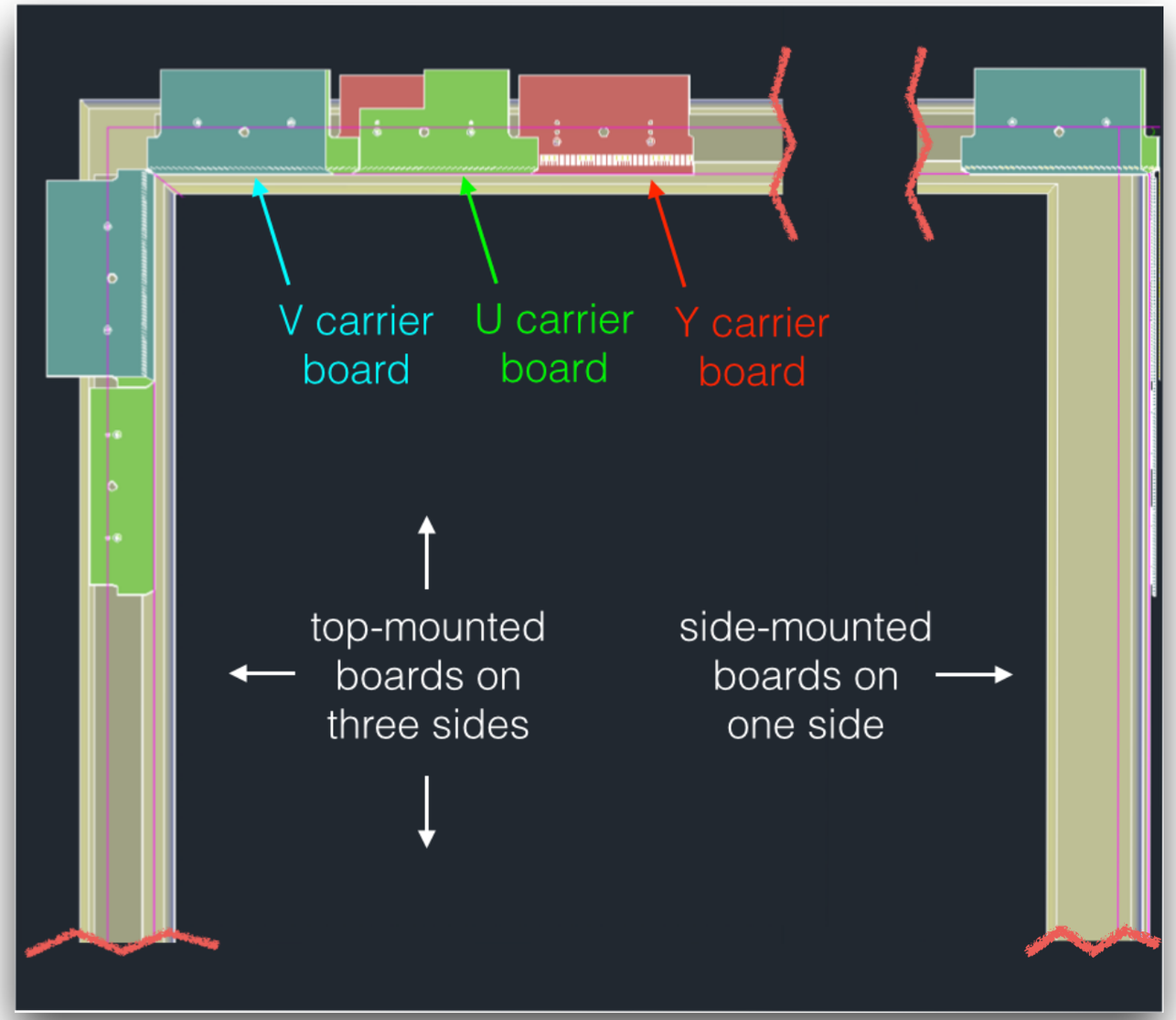
deflector board

strips held at few hundred volts potential

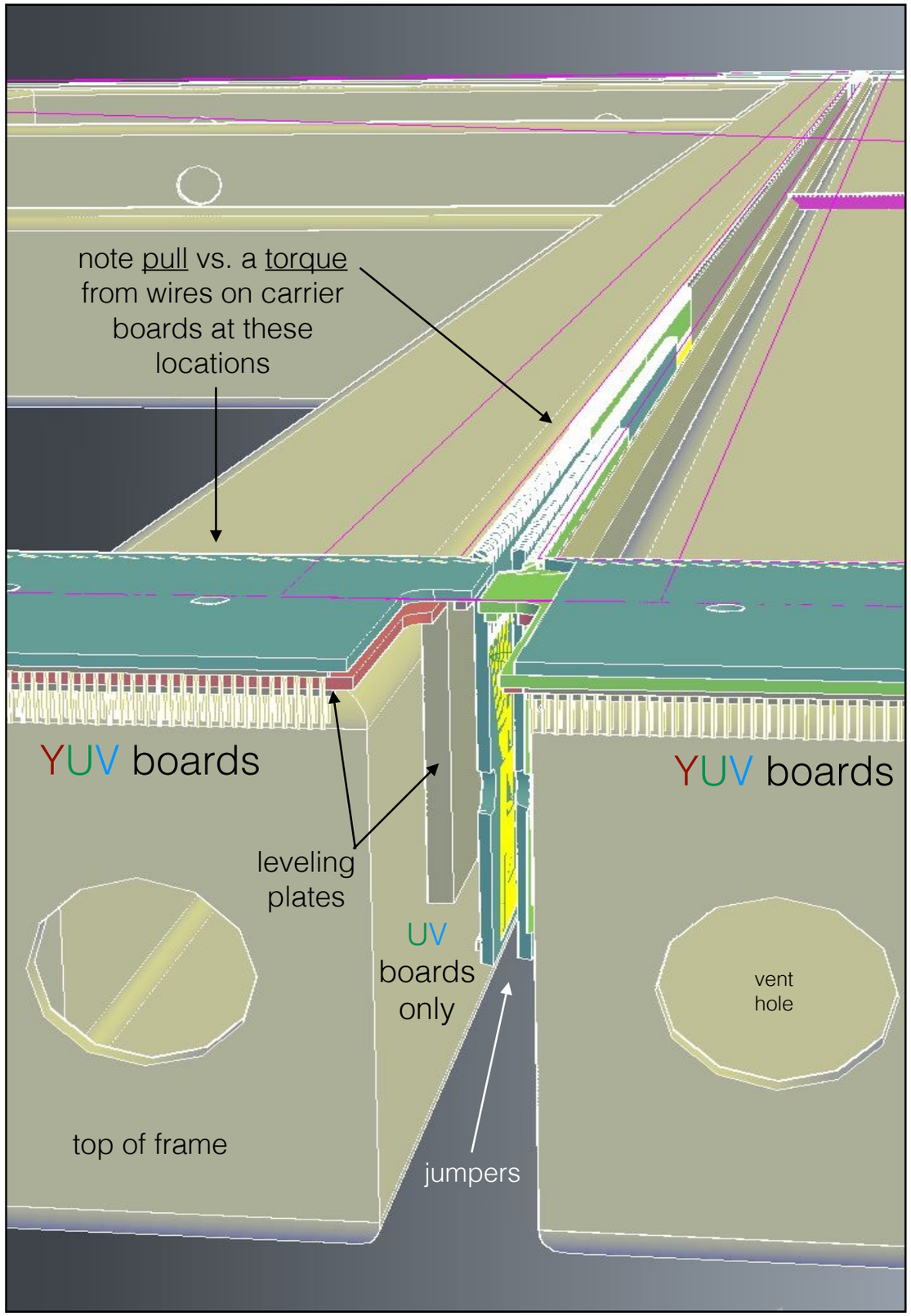
Minimize total readout channels

Minimize dead space between tiled APA frames

The Wire Mounting “Stack”



±2 mm on the frame construction is impressive, but we’ll need better for 3 mm wire plane separation



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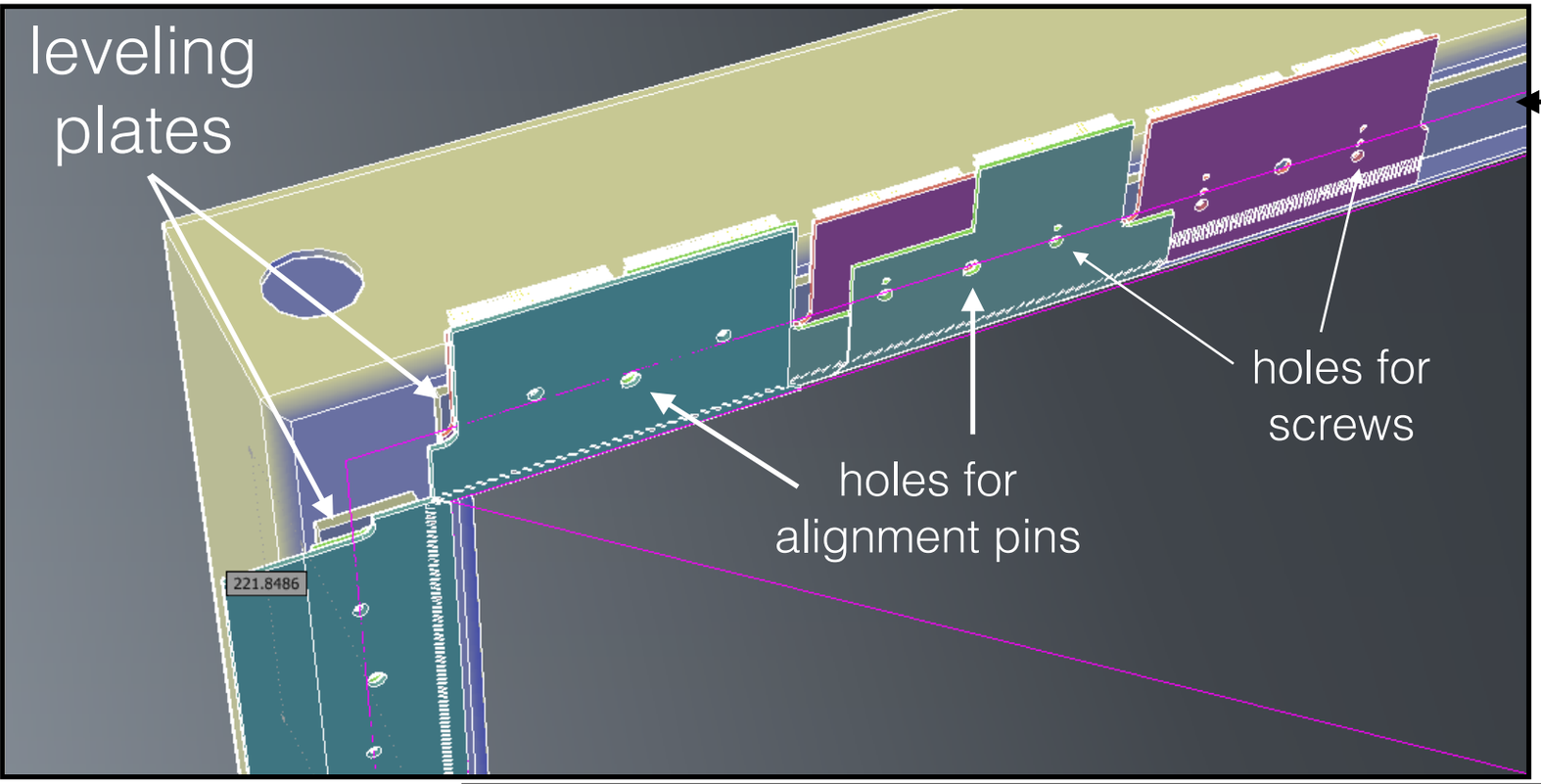
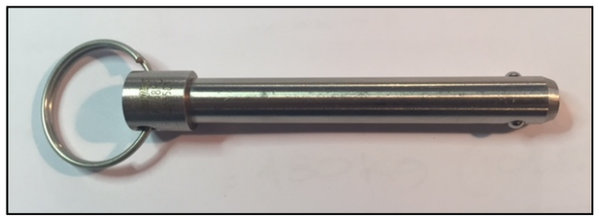
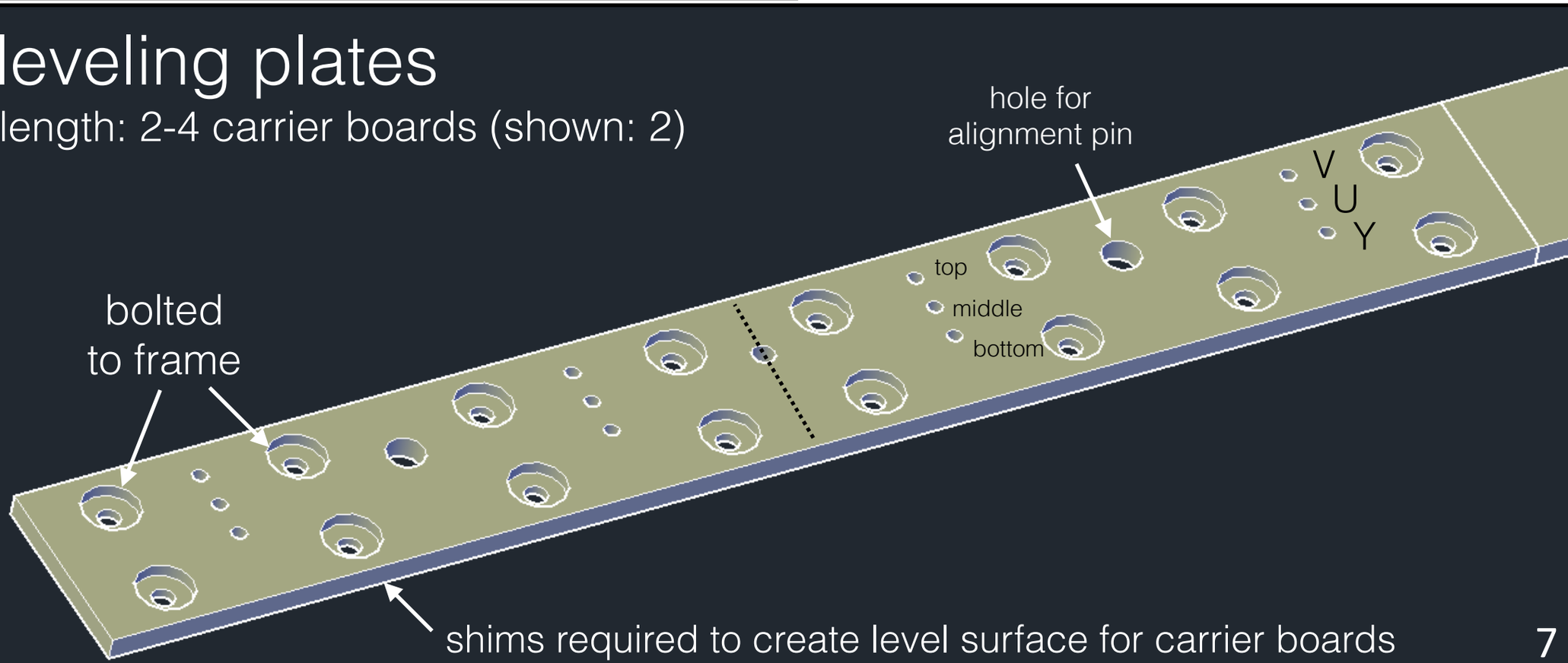


leveling plates



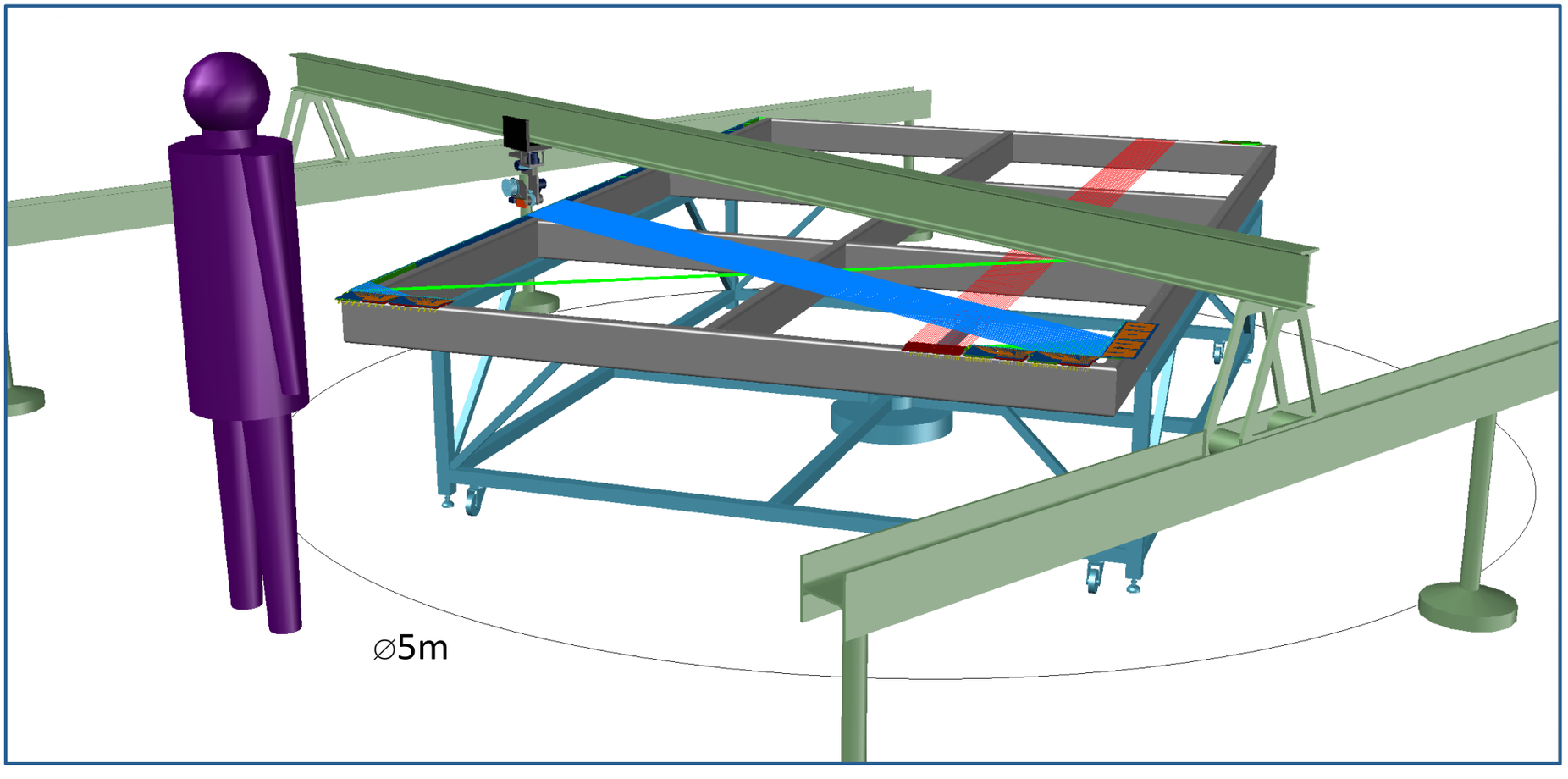
leveling plates

length: 2-4 carrier boards (shown: 2)



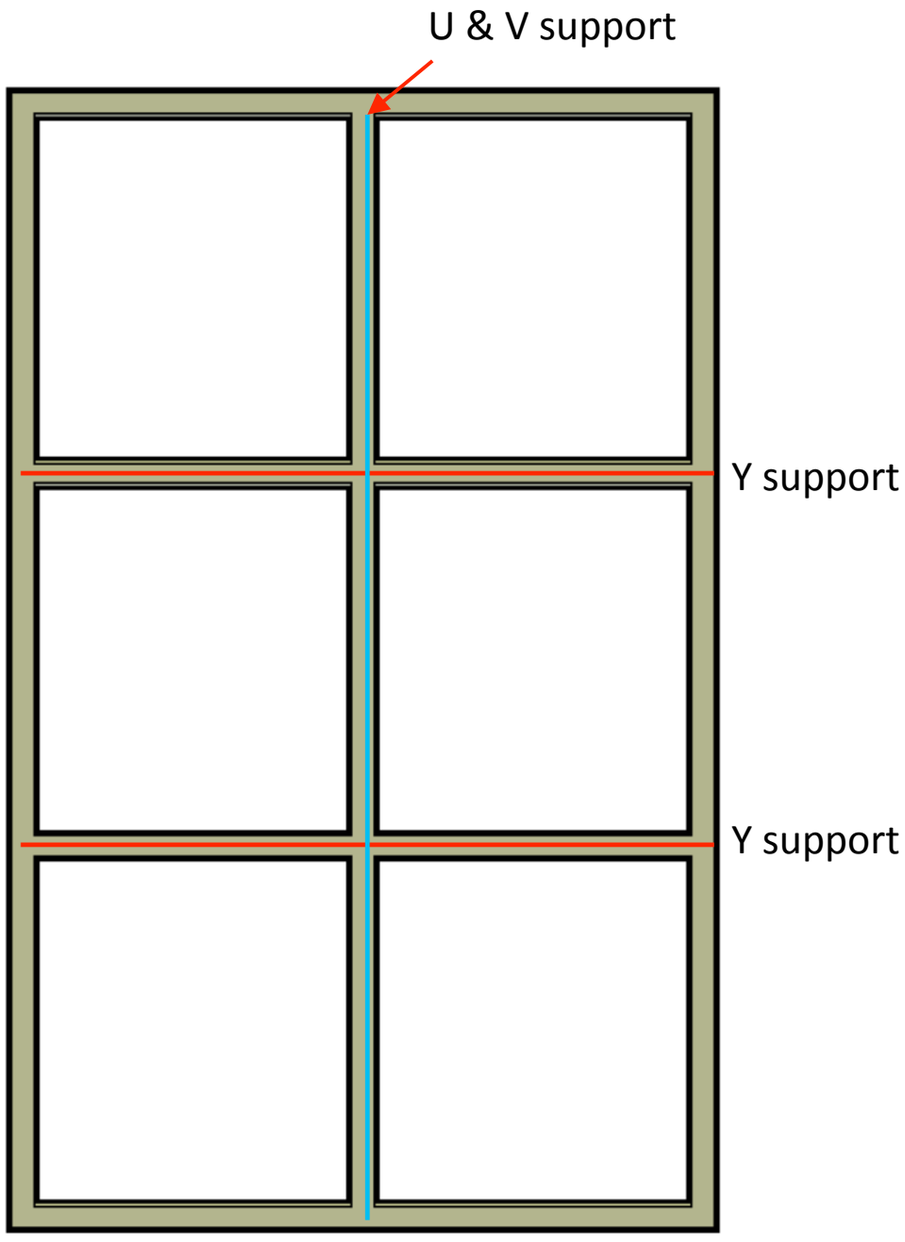
APA Wire Stringing

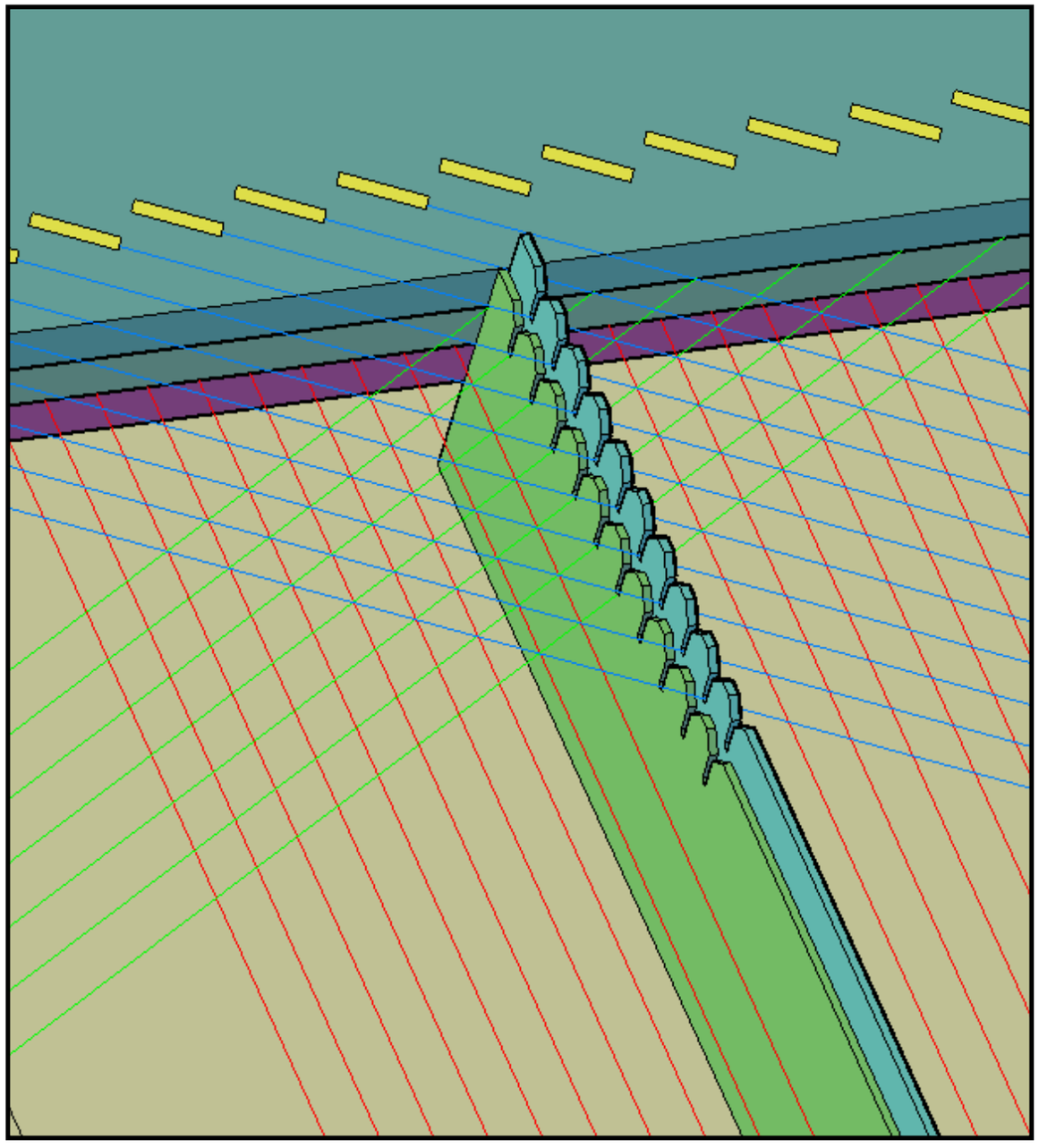
- **For SBND, wire stringing will take place in US and UK**
  - Procedures being developed now by Manchester and Syracuse groups
- **Image below from Manchester semi-automated design:**
  - Frame supported on turntable device - rotates to three working angles
  - Wiring head traverses on cross beam, which itself travels on fixed side rails
  - Computer controlled stepper motors ensure precise positioning
- **For wire stringing in US, communicating with PSL regarding use of techniques developed for DUNE efforts (i.e. 35 ton). See Lee's talk next.**



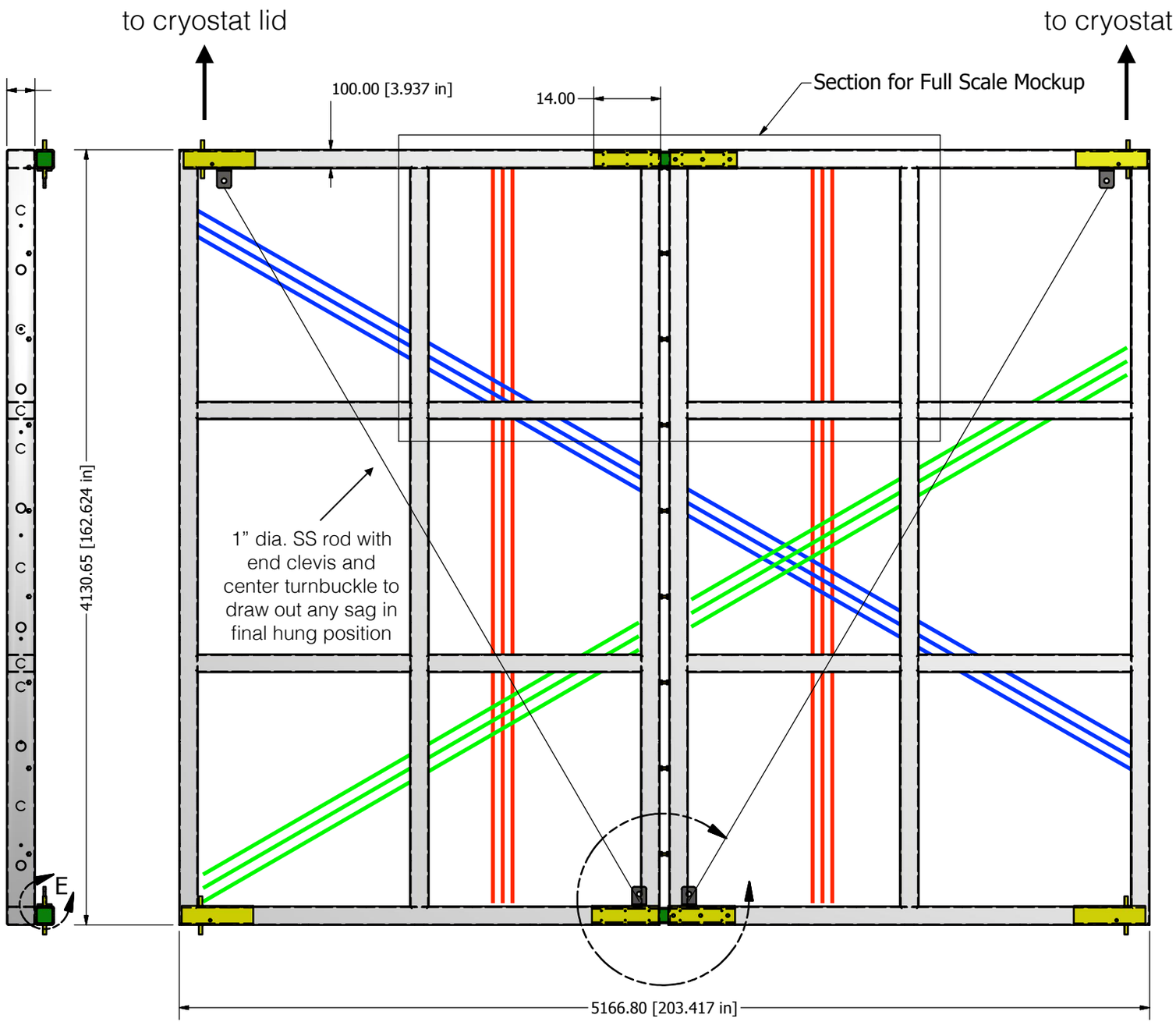
Wire Support Combs

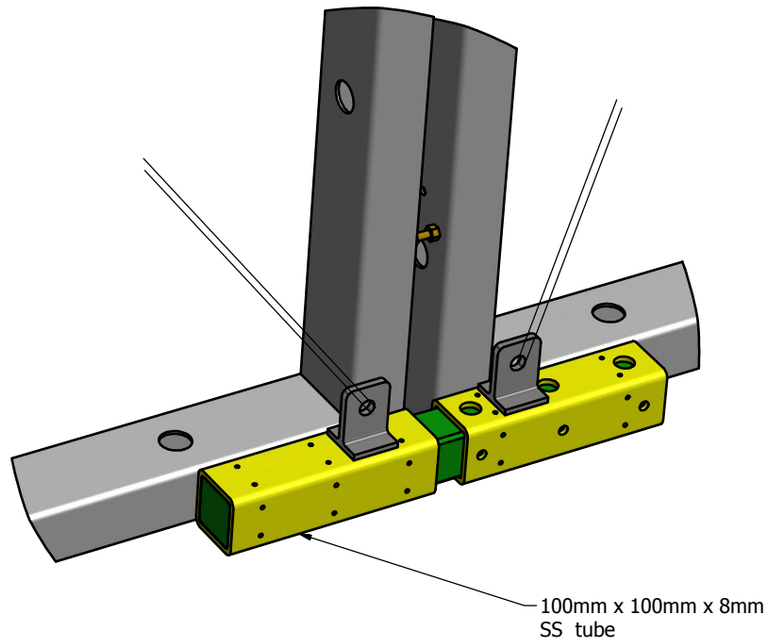
- **Keep unsupported wire length < 1.5 m**
  - minimize wire sagging, deflections to maintain uniformity across planes
  - control a wire in the case of breakage

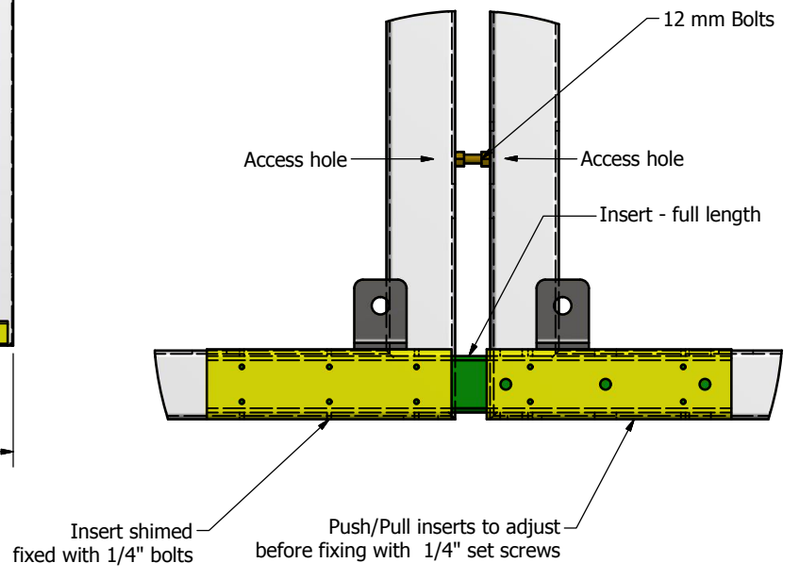




Connecting APA Frames







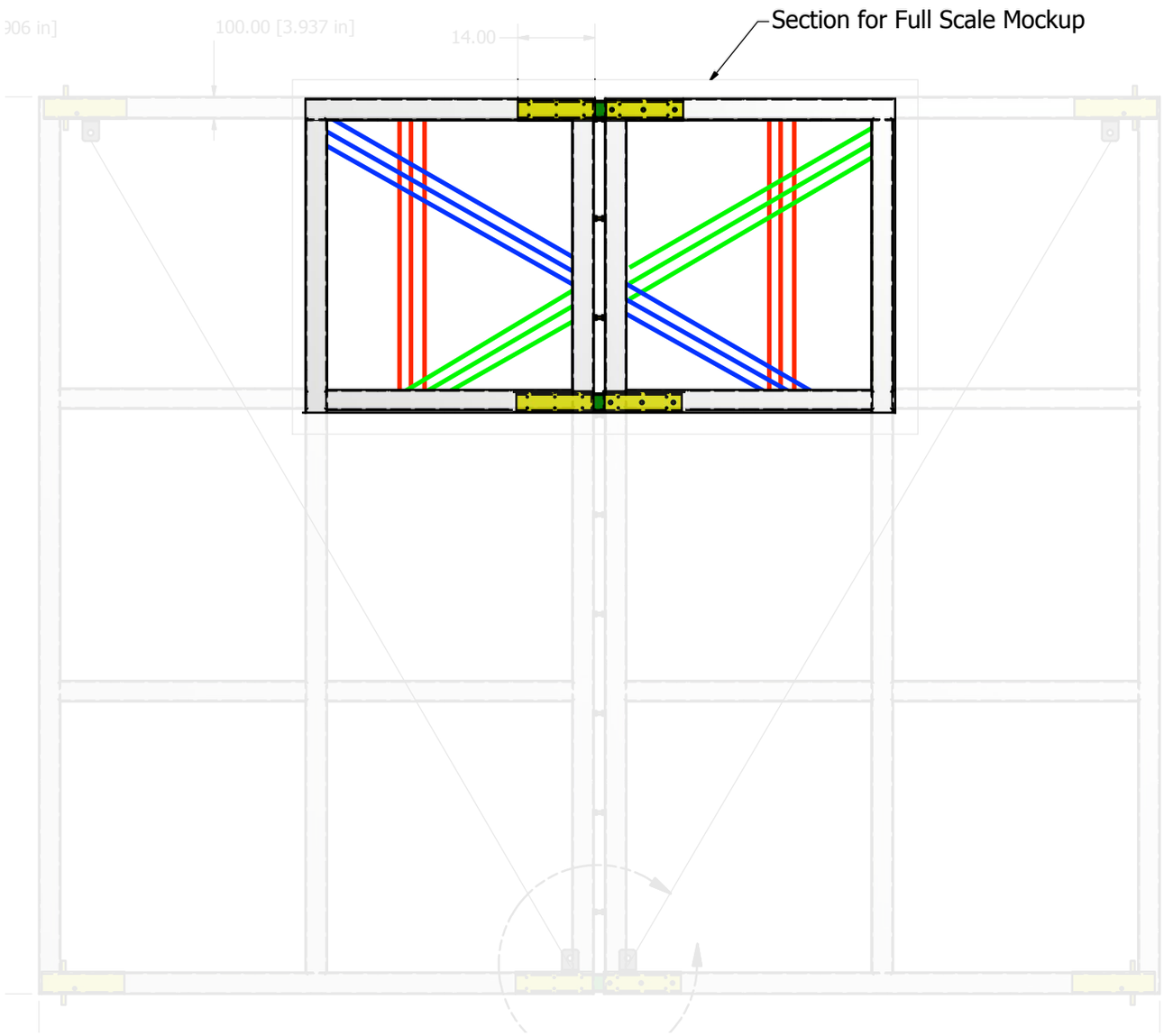
Gap controlled with threaded connections along edge

Adjustable connection bar designed to control angle, alignment between APAs

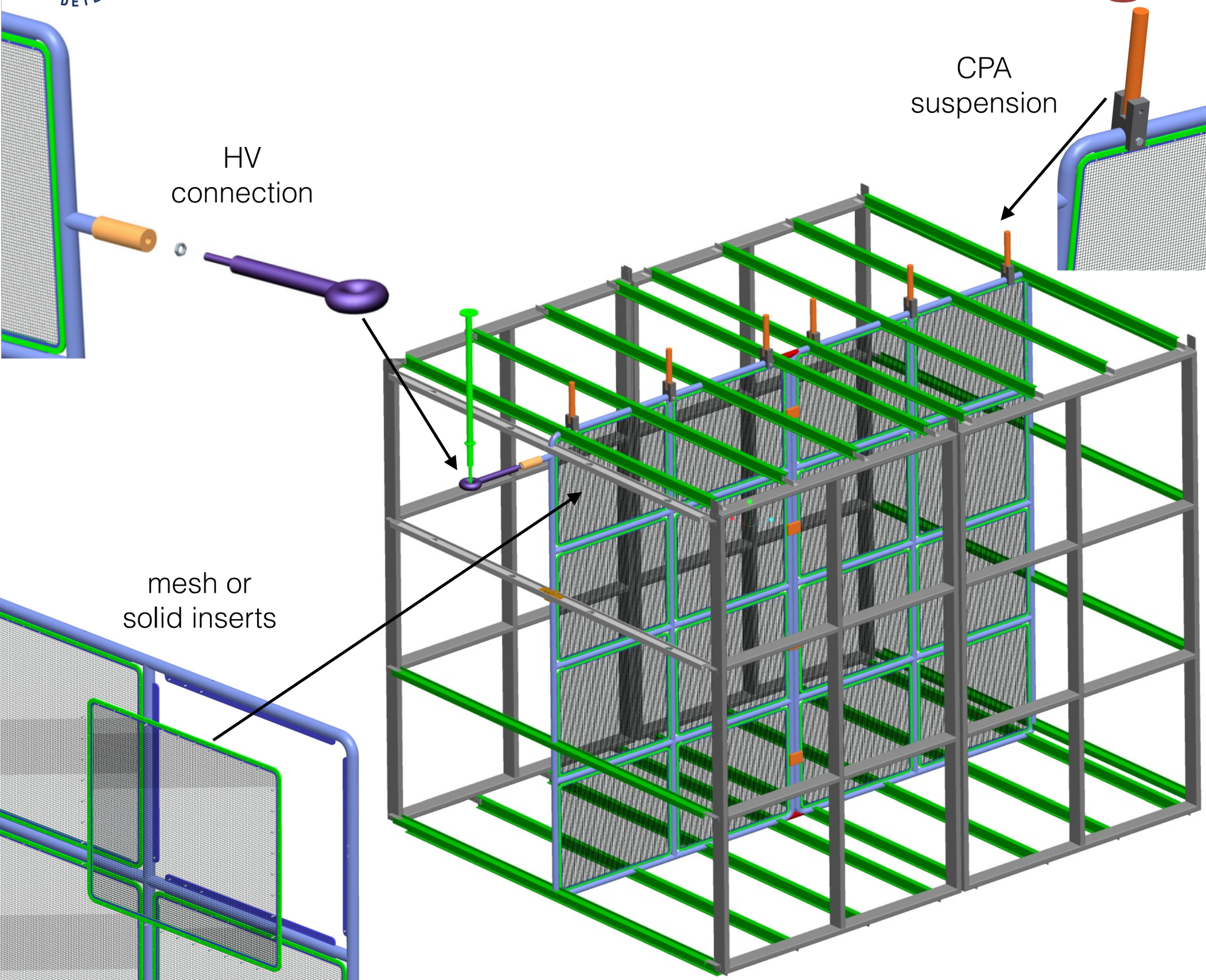
Double-APA suspended at two outer corners only (minimize connection to lid deformations)

APA Prototype

- **Plan to begin construction soon of a full-scale “single window pane” prototype to test:**
  - Mechanical construction of APA frame
  - Survey and shim leveling plates, wire carrier board installation
  - Wire stringing
  - Double APA assembly and alignment, ensure uniform gap and coplanarity, jumper installation
  - Tests of wire integrity
  - Test fit light collection mounting scheme and hardware
  - Other prototyping being considered



Cathode Plane Design



APA Challenges/Questions

Many important design, construction, and QA issues to be addressed

Lots of work ongoing within SBND to address these issues and more

- **APA frames and wire mounting boards**
  - Ensure wire plane flatness across large frames
  - Assembly and installation procedures with large, delicate structures
  - Alignment and coplanarity between neighboring APAs - especially when jumping U/V wires
  - Minimal distortions under wire tension and weight forces including self weight, field cage, light collection, cabling, etc.
- **Wire stringing procedures and tooling**
  - Stretching and glueing of mesh layer under wire planes
  - Wire tensioning, soldering, epoxying procedures

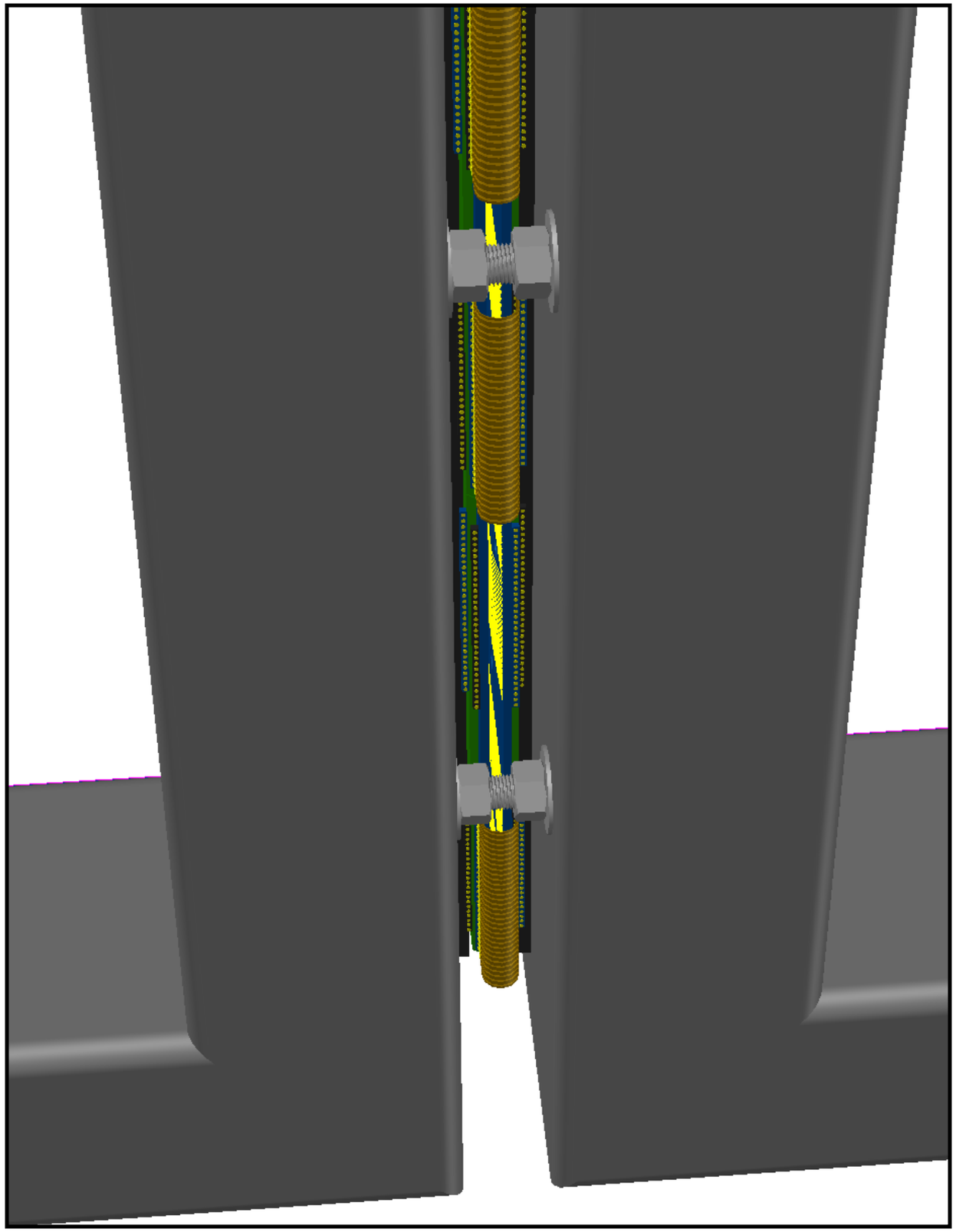
APA Challenges/Questions

Many important design, construction, and QA issues to be addressed

- **Quality control**
  - How best to survey wire tensions and positions (automation)? How best to log and use this information?
  - Continuity testing of each wire through to its readout? Wire bias tests before installation?
  - Is cold testing of each built frame required? If so, what is the facility and procedure? What measurements should be made?
- **Long-term operation**
  - Long-term robustness of solder/epoxy connections
  - Intermediate wire combs to maintain plane uniformity and control wires in case of breakage
- **Role of prototypes to learn what we need to learn?**

Extras

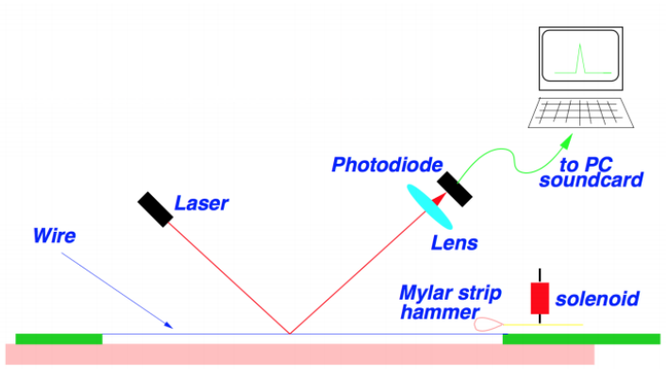
APA Jumpers



Wire Tension Measurements

- The wires have a diameter of 150 µm and are made of CuBe
- Wire tension of 0.5 kg at room temperature
- Wire lengths vary from centimeters up to 4 meters
- need to measure many 1000s of wires

We need a method that can perform a fast and precise measurement of the tension

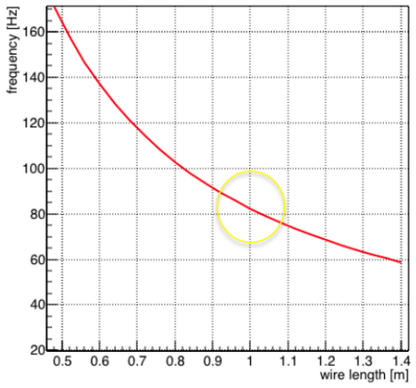


Idea: the wire fundamental frequency is excited by a very short mechanical hit and the induced vibration is detected by a laser–based optical system

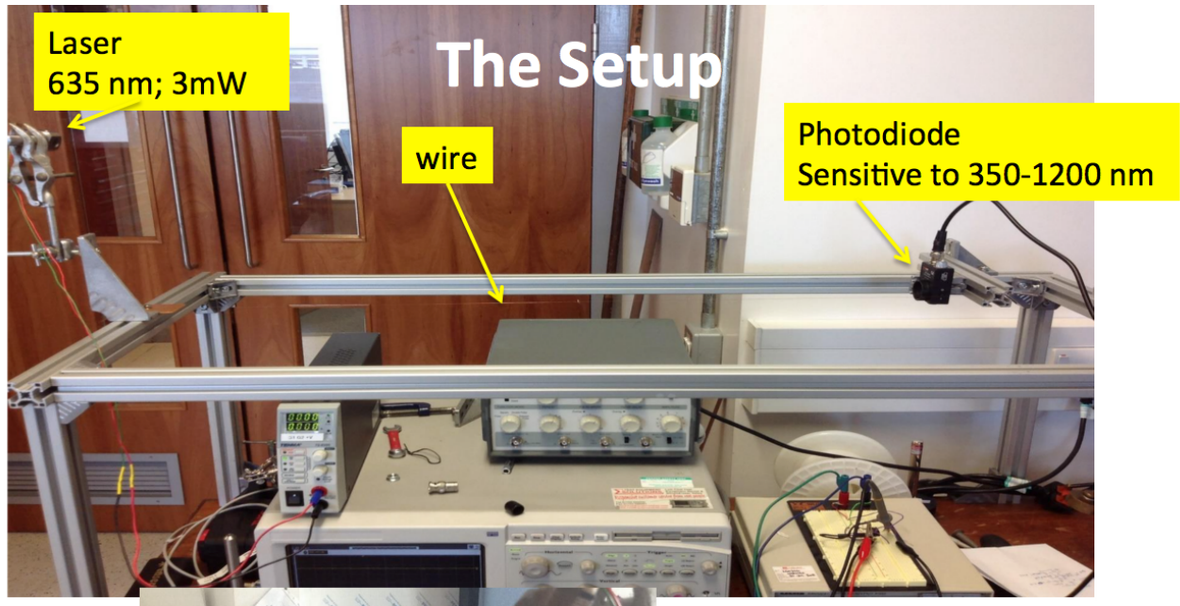
$$T = 4\mu l^2 f_0^2$$

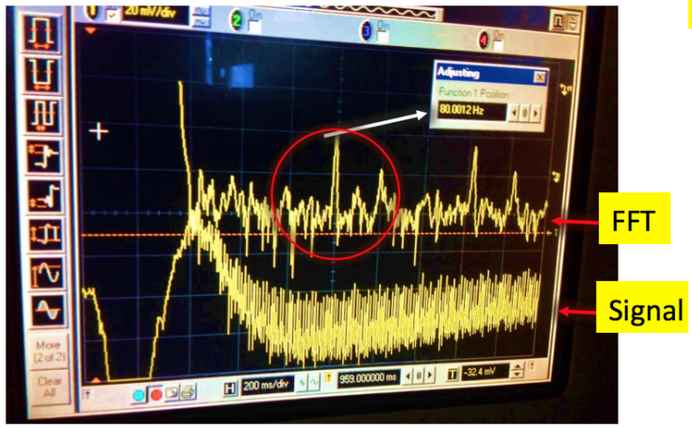
l = wire length
T = mechanical tension
f_0 = fundamental frequency
µ = wire linear mass density

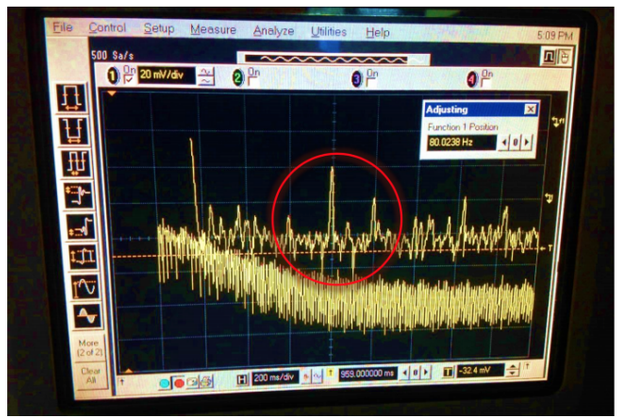
For a mass of 0.4 kg and a length of 1 m (our test-setup)



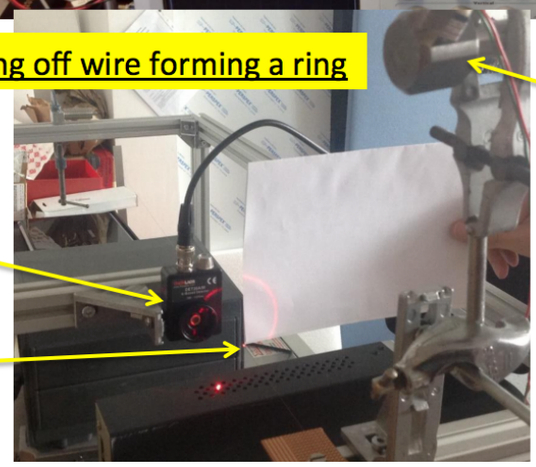
$$T = 4\mu l^2 f_0^2$$





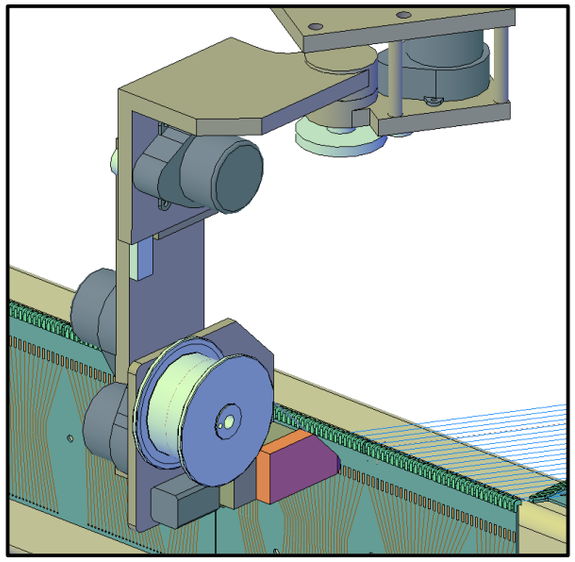


Laser reflecting off wire forming a ring

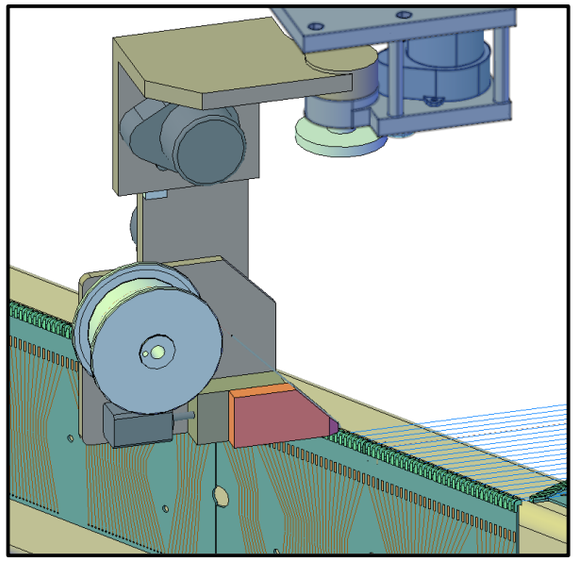


Wire Stringing Tooling/Process

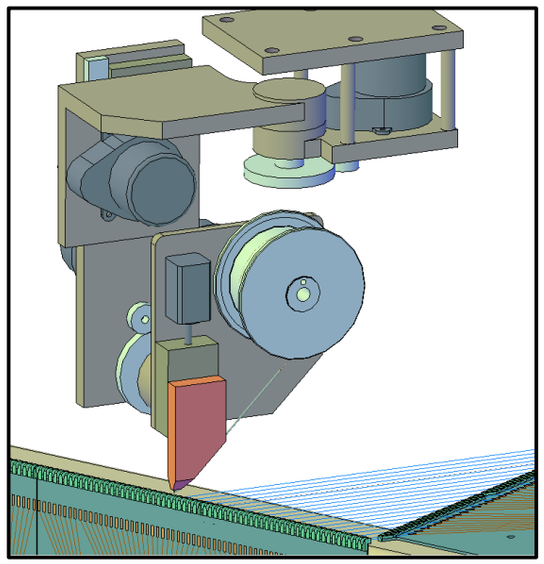
Wiring Head



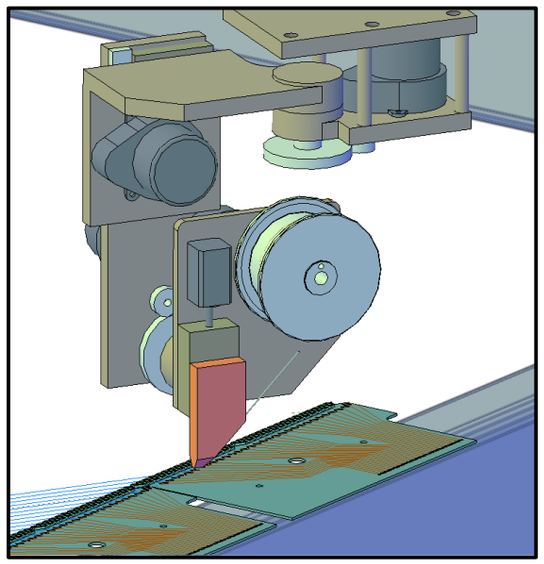
1. Make first joint perpendicular to board



2. Move up and rotate to angle of wire

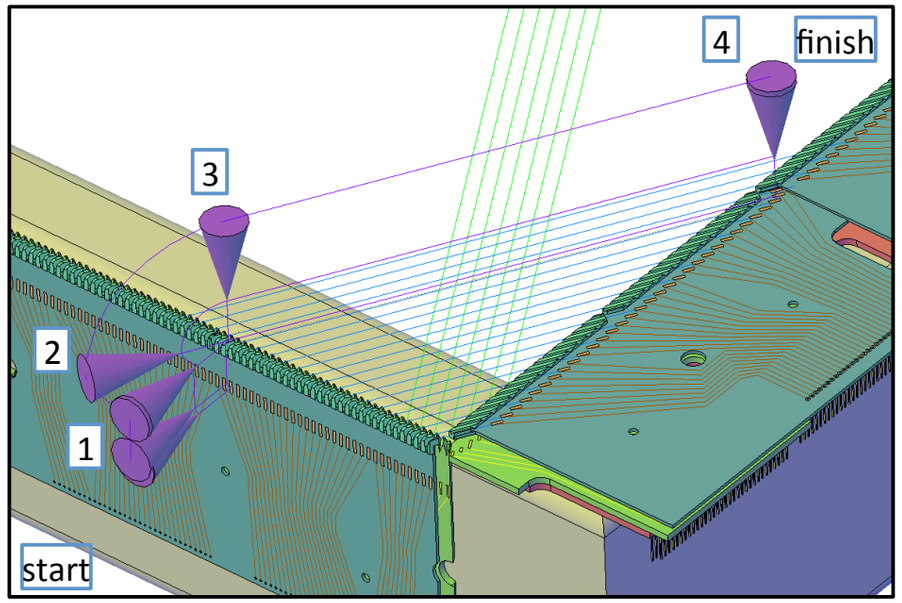


3. Move out and swing round edge



4. Traverse to end pad and make final joint

Simple movement for Y wires, more complicated for U & V.



Path for ‘U’ wires

Wire Carrier Boards

- **Several different board layouts required in SBND APAs**
  - U,V,Y
  - top/bottom vs. sides
  - outside edge vs. adjoined edge